MINERALOGY OF SULFIDE-BEARING VUGS IN THE GIBEON IVA IRON Michail I. Petaev[1], Ursula B. Marvin[1] and Marvin Killgore[2], [1]Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, [2]Southwest Meteorite Lab, P.O. Box 95, Payson, AZ 85547

Recent observations of numerous vugs lined with crystals in the Albion IVA iron [1-5] raise the question of how abundant are such vugs in other IVA meteorites? The lack of previous reports on vugs in iron meteorites clearly indicates that they are not very common in the meteorite sections studied so far, so a search for such rare objects would require extensive meteorite slicing, which is both time-consuming and expensive. Fortunately, the group of IVA meteorites includes Gibeon, which is one of the largest and best-selling meteorites worldwide. Hundreds of 3-5 mm thick slices of large Gibeon specimens are being cut annually in the Southwest Meteorite Lab for commercial purposes. Only a few of them contain vugs.

Here we report the results of investigations of slice V (100×60×3 mm) which contained two rounded vugs (Fig. 1) penetrating almost through the thickness of the slice. The vugs were roughly half-filled with loosely- packed spheroids 0.2 - 0.5 mm across. In addition to spheroids, the larger one, Vug A, contained an euhedral cubic crystal ~3 mm across attached to the wall. The crystal was coated by a much finer-grained material reminiscent of epitaxial overgrowths. Two spheroids that stuck together were easily picked out of Vug A by a needle before cutting off the ~2×3 cm portion of the slice for section preparation. To allow BSE imaging of the interior of Vug A, its narrow opening was widened by use of a hand drill equipped with a conical grindstone. The polished section prepared by a traditional technique was thoroughly washed and repeatedly ultrasounded in acetone and alcohol to remove polishing compound and possible contamination. Unfortunately, the euhedral crystal and most of the spheroids were lost during these procedures and could not be recovered among residues in the final washes.

In addition to large rounded vugs, the polished section contains three brassy, sulfide-rich masses near Vug B (Fig. 1, upper left corner) and several relatively large euhedral-to-subhedral chromite grains. These, along with smaller daubréelite, daubréelite-silica, and brezinaite-daubréelite inclusions, are described in some detail in the accompanying abstracts [6-8].

The interiors of both vugs still retain some spheroids stuck to the walls and to each other (Fig. 2). The occurrence of loosely-packed spheroids in the vugs suggests that at some point minute spheroids were suspended in a fluid media before settling into vugs after removal of the fluid. At least some spheroids have very lumpy surfaces suggestive of a high porosity. Both vugs have a ‘canal’ narrowing downward, which might serve as a pathway for a fluid phase once present in vugs.

The polished section of the two spheroids extracted from Vug A (Fig. 3) shows that the spheroids consist of loosely packed inequigranular, irregular metal and sulfide grains and aggregates. A closer view (Fig. 4) displays a fine-grained metal-troilite groundmass (Fe-FeS eutectic?) with embedded rounded or angular daubreelite grains and abundant voids of varying dimensions. Larger voids are partially filled with Fe,Ni-oxides, probably of terrestrial origin. No euhedral mineral grains were observed in the spheroids; this is in drastic contrast with those of Albion. The lumpy texture of spheroids suggests their formation due to accumulation of detrital mineral fragments and intergrowths without subsequent cementation, rather than crystallization from a melt or condensation from a fluid phase.

Metal grains include high-Ni taenite (54 - 56 wt.% Ni) and low-Ni kamacite (2-3.3 wt.% Ni; 0.1 -0.3% Cr). The large daubréelite grains are close to the ideal formula $FeCr_2S_4$, whereas smaller ones show a slight Fe excess, probably due to contamination with surrounding metal. Troilite analyses are always contaminated with metal, and their Cr content varies from 0.19 to 1.04 wt.%. The following modes (vol.%) were estimated from BSE images: for the large spheroid: kamacite (23), high-Ni taenite (10), troilite (35), daubréelite (15), Fe oxides and voids (18); for the small spheroid - kamacite (13), high-Ni taenite (16), troilite (33), daubréelite (16), Fe oxides and voids (22).

The genesis and the nature of the precursor material of the vugs remain unclear. The coexistence of high- and low-Ni metals is consistent with their equilibration at ~400°C in the presence of Fe sulfide [9]. The low Cr contents in troilite in the presence of daubréelite and metal also points to a low equilibration temperature, although this could be alternatively explained by the lack of equilibrium among these three minerals during a short secondary reheating of this assemblage. The large amount of a fluid phase required to account for the abundant empty space in the vugs and the high porosity of the spheroids might promote equilibration among the spheroid’s minerals at low temperatures. A sudden opening of the vugs and immediate escape of the fluid phase might have resulted in an explosive fragmentation of primary mineral assemblages in the vugs, followed by their accumulation into spheroids and subsequent sedimentation in the vugs. The low gravity expected on the parent body of IVA irons might play a key role in suspending mineral fragments and spheroids even in a low density fluid or gas.

In conclusion, whatever the nature and origin of the Gibeon vugs may be, the observation of them indicates that the formation of these rare objects was a planetary-wide process on the IVA parent body, while each vug has been formed in accordance with local physical-chemical onditions.

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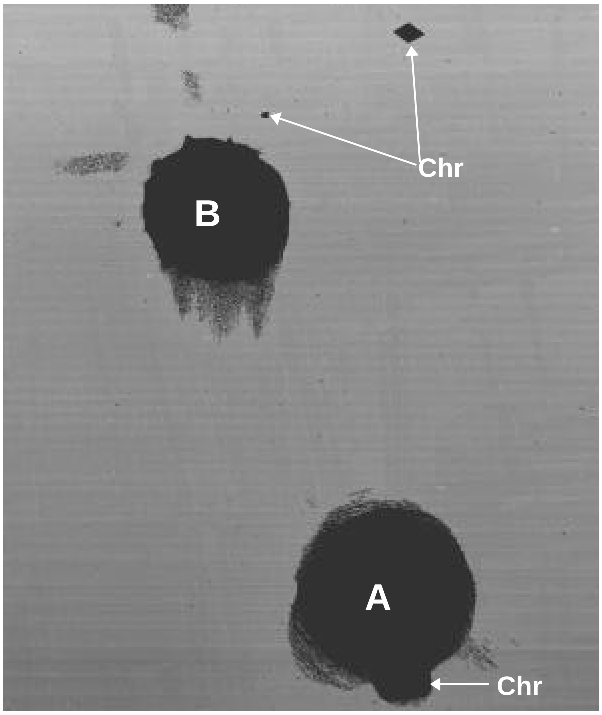

Fig. 1. Portion of the Gibeon section studied. View of 18.7×29.6 mm. BSE image. Horizontal bands and minor variations in gray shade of the background metal are imaging artifact. Shaded halos around the vugs are unpolished areas left after cutting the meteorite.

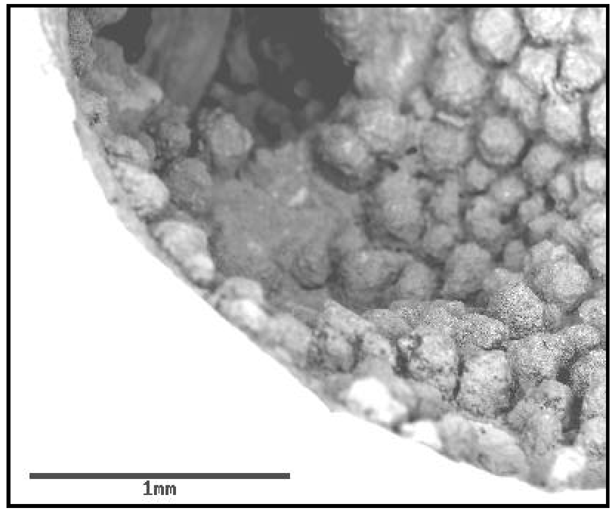

Fig. 2. Spheroids in Vug B. BSE image. White = background metal. Upper right corner of the image is slightly out of focus due to large depth of the vug. Spheroids in the well-focused bottom right corner display lumpy surfaces indicative of a high porosity. Darker area at the upper center is the 'canal' narrowing downward.

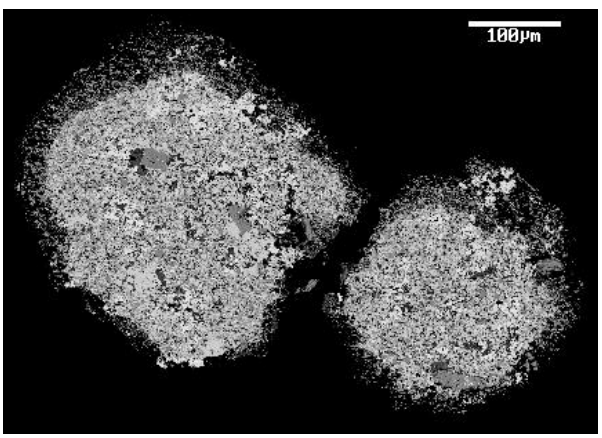

Fig. 3. Spheroids from Vug B. BSE image. White = metal, light gray = troilite and fine-grained metal-troilite intergrowths, gray = daubréelite, black = voids and Fe oxides.

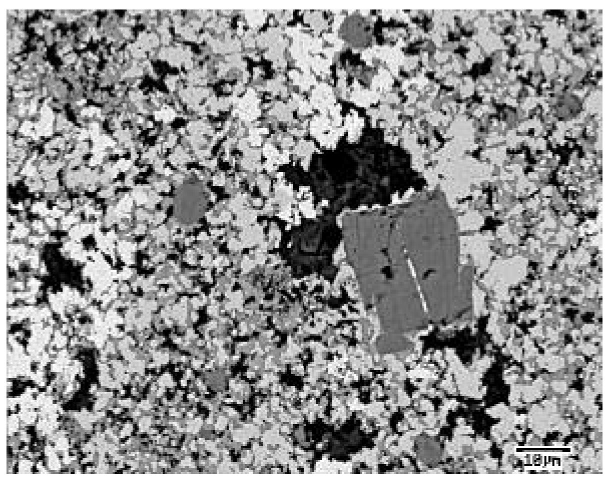

Fig. 4. Structure of the large spheroid. BSE image. White = high-Ni taenite, light gray =low-Ni kamacite, medium gray = troilite, gray = daubréelite, black = voids and Fe oxides.